

VZCZCXYZ0007  
PP RUEHWEB

DE RUEHC #2291 3031800  
ZNY SSSSS ZZH  
P 301737Z OCT 09  
FM SECSTATE WASHDC  
TO AMEMBASSY PARIS PRIORITY 0000  
MISSILE TECHNOLOGY CONTROL REGIME COLLECTIVE

S E C R E T STATE 112291

SIPDIS  
PARIS FOR POL: NOAH HARDIE  
BRASILIA FOR POL: JOHN ERATH

E.O. 12958: DECL: 10/30/2034  
TAGS: [MTCRE](#) [ETTC](#) [KSCA](#) [MNUC](#) [PARM](#) [TSPA](#) [FR](#)  
SUBJECT: MISSILE TECHNOLOGY CONTROL REGIME (MTCR):  
EMERGING TECHNOLOGIES FOR MTCR CONSIDERATION

Classified By: ISN/MTR Director Pam Durham.  
Reasons: 1.4 (B), (D), (H).

¶1. (U) This is an action request. Please see paragraph 2.

¶2. (C) ACTION REQUEST: Department requests Embassy Paris provide the interagency cleared paper "Emerging Technologies for MTCR Consideration" in paragraph 3 below to the French Missile Technology Control Regime (MTCR) Point of Contact (POC) for distribution to all Partners. Info addressees also may provide to host government officials as appropriate. In delivering paper, posts should indicate that the U.S. is sharing this paper as part of our preparation for the Information Exchange that will be held in conjunction with the MTCR Plenary in Rio, November 9-13, 2009. NOTE: Additional IE papers have been provided via septels. END NOTE.

¶3. BEGIN TEXT OF PAPER:

SECRET//REL MTCR  
Emerging Technologies for MTCR Consideration

#### Introduction

Emerging technologies used in the development, manufacture and production of missiles force us to think about how they may impact Missile Technology Control Regime (MTCR) controls. Some of these changes are subtle, relying on improvements to materials and methods of manufacture, while others are more dramatic. As technological advances occur, and become more commonly available, Partners need to consider whether to change MTCR controls to keep pace. This paper seeks to highlight technologies that are not covered by the MTCR Annex but could make an important contribution to a country's missile program. It also will examine the limitations of some current MTCR Annex controls that may reduce the ability to prevent the proliferation of technologies useful in the development of WMD delivery systems.

#### Electron Beam and Laser Welding

Both laser and electron beam welders offer precise control of the welding process through complete scalability of the weld beam, allowing welding of everything from thin foils to thick parts. Although these technologies are widely used in commercial applications, welding technology also is critical to ballistic missile manufacturing where some materials may be very thick and others may be very thin or made of reactive metals. Both types of welders -- laser and electron beam -- are appropriate for a wide range of metals (steel, titanium, aluminum, and others), and can be used to weld dissimilar metals, a process that is extremely challenging using traditional forms of welding. However, despite their critical importance in ballistic missile manufacturing, they are not controlled by the MTCR.

Electron beam welding (EBW) is a process in which a high-

velocity beam of electrons is directed at the materials to be joined, heating the material to approximately 25,000 degrees C and fusing them, while allowing for very fine control over the weld properties. This creates a much stronger weld than can typically be created using other welding methods. EBW is also able to create these same high quality welds for thick workpieces.

EBW is often performed in a vacuum or in a controlled atmosphere where inert gases are introduced into the welding chamber. This is done to displace oxygen from the atmosphere that can react with the molten metals to create oxides that weaken the weldments. High-purity welds are the key to obtaining maximum material strength in the welded joint. The tightly focused energy of the weld beam causes deep penetration into the workpiece while minimizing the heat affected zone (HAZ). This preserves much of the material properties of the parent material for maximum strength.

Welders of this type comprise several components that together form the weld system, including an electron beam gun and the weld chamber. An electron beam gun is used to produce the electrons and accelerate them. The weld chamber is a strong, leak-proof cabinet that can withstand the pressures of being put under vacuum while still providing an access for installing and removing the workpiece to be welded. The weld gun and working chamber will usually have separate vacuum pumps. The workpiece will be manipulated many times within the chamber through the use of computer numeric controls (CNC) that are connected to servo motors.

EBW is especially useful for the manufacture of large casing structures and propellant tanks for ballistic and cruise missiles and in the welding of regeneratively cooled nozzles for liquid rocket engines.

Laser Welders are similar to EBW except a laser is used to project a focused beam of photons at the workpiece instead of electrons. Solid state and gas lasers are commonly used. A high power density beam concentrates its energy on a small area. The energy of these photons is similar to that of electron beam welding and is converted to heat when impacting on the part. One potential downside to using laser welders is the tendency of metals to scatter and reflect some of the laser energy. Lasers do, however, provide a very controlled weld and offer a small HAZ. Pulsed laser beams are used for thinner metals while a continuous beam is used to weld thicker metals. In this way all types of metals from foils to thick plates can be successfully welded using lasers. Unlike electron beam welders, some laser welders can be used outside a vacuum or controlled atmosphere, making them somewhat more versatile. Laser welders also can be mounted on robotic arms, making them suitable for parts with areas that are difficult to access.

Laser welding is used in the fabrication of missile launch canisters, missile antenna systems, and to weld aerodynamic surfaces to missile bodies.

#### Exploitation of Satellite Navigation Receivers in WMD Delivery Systems

Since the early 1990s, the MTCR Annex has included language intended to control the proliferation of military and commercial satellite navigation receivers that could be used in platforms capable of carrying WMD. Global Navigation Satellite System (GNSS) receivers are frequently used in UAV applications, including cruise missiles. However, cruise missiles and UAVs can use receivers that are uncontrolled by the Annex and are virtually indistinguishable from those used in a variety of commercial applications. Controls designed to restrict GNSS receivers useful in ballistic missiles based on an operating velocity threshold can be effective, but care must be taken to ensure consistent enforcement of these velocity limitations.

The Potential Threat: The U.S. Global Positioning System

(GPS, with both military and commercial signals) is the only fully operational GNSS presently available, although Russia, Europe, and China are developing similar systems. The intrinsic accuracy of GNSS is high, even using just the commercial signals, which provides for overall missile system accuracies on the order of a few meters. Moreover, these errors do not grow with time of operation or range of the platform, as do inertial navigation system (INS) errors. Therefore, GNSS data is often used in missile navigation systems, including for cruise missiles and UAVs, to periodically correct for INS errors. Countries such as Iran and Syria could potentially use GNSS receivers to achieve weapon accuracies more than an order of magnitude higher than possible using only INS.

Controls on GNSS Equipment in the MTCR Annex: GNSS receivers, and Inertial Navigation Systems that incorporate GNSS equipment, applicable for use in missiles are controlled in the MTCR Annex under Items 9.A.7, and 11.A.3. MTCR Annex Item 11.A.3. currently controls GNSS receivers designed or modified for use in Category I systems or designed for airborne applications that are capable of providing navigation information at speeds in excess of 600 meters per second, employing decryption to gain access to GNSS secure signal/data, or being specially designed to employ anti-jam features. MTCR Annex Items 11.A.3.b.2. and 11.A.3.b.3. have helped prevent the proliferation of military-grade receivers that make use of the encrypted GPS military signals and of antennas that reduce the effective power of jamming sources. However, Item 11.A.3.a -- which controls GNSS receivers that are designed or modified for use in platforms having ranges greater than 300 km and capable of carrying 500 kg in payload -- covers relatively little because GNSS receivers are rarely designed or modified for MTCR applications. Additionally, the performance of GNSS receivers, or navigation systems incorporating GNSS receivers, does not degrade with the range or payload capability. Therefore, a GNSS receiver designed for a shorter-range UAV or cruise missile would also be usable in a Category I system. Moreover, many uncontrolled receivers can be used in UAVs and cruise missiles without any modification, and engineers from most countries of concern (many of whom attend international GNSS conferences) should have no trouble connecting the relevant outputs to the vehicle's autopilot after obtaining the receiver.

Item 11.A.3.b.1. -- which controls receivers capable of providing navigation information at speeds in excess of 600 m/s -- has the potential to serve as an effective control on ballistic missile use of GNSS since reentry vehicles, even for short range ballistic missiles, achieve substantially higher speeds. However, manufacturers have implemented this restriction unevenly over the years, allowing the speed restriction to be removed after sale in some cases. For example, the manufacturer of one receiver provides it with the MTCR control limit of 600 m/s as the default speed limit, but allows the user to reprogram this limit. A potential solution to this reprogramming problem would be to implement this limit in firmware, which would be less susceptible to tampering, rather than in the software. However, given that the number of countries now producing chips for GNSS receivers -- and the receivers themselves -- continues to grow, the effectiveness of 11.A.3.b.1. could significantly diminish given the difficulty of ensuring that all the potential manufacturers include the same limitations in their equipment. Furthermore, shareware receiver designs -- including even those being developed in universities -- are likely to add to this problem.

Additionally, the 600 meters per second criterion in Item 11.A.3.b.1. was designed to capture GNSS receivers used in ballistic missiles and high-speed cruise missiles, while the criteria for decryption and anti-jam features in Items 11.A.3.b.2. and 11.A.3.b.3. were geared toward GNSS receivers designed for military or governmental use. However, the current control text does not cover commercial GNSS receivers usable in slower moving UAVs, including many cruise missiles. (Note: 600 meters per second is approximately Mach 1.76, while the vast majority of UAVs, including a wide variety of

cruise missiles, operate below Mach 1.0.) Partners should be aware that most commercial GNSS units sold for airborne applications do not meet the MTCR parameters but are nevertheless useful for and used in Category I and II UAV and cruise missile systems.

#### Accelerometers and Gyros

Accelerometers and gyroscopes with performance poorer than those subject to control under the MTCR can still be useful for accurate navigation of Category I and II missiles and UAVs. MTCR Annex Item 9.A.3. controls accelerometers with a specified scale factor and bias repeatability, and 9.A.4. controls gyros of a specified drift rate stability. However, particularly for unmanned aerial vehicles (UAVs), including cruise missiles, there is an increasing use of integrated navigation systems incorporating an inertial navigation system (INS) with a GNSS receiver. These systems use the GNSS receiver to correct for errors in the output of the INS accelerometers and gyros. Therefore, it is possible to incorporate non-MTCR-controlled gyros and accelerometers with large time dependent errors into a highly accurate GNSS-aided INS for use in Category I and II UAVs, including cruise missiles. For example, many compact INS units for small UAVs currently use MEMS gyros and accelerometers that do not meet the MTCR parameters, yet in conjunction with a GNSS receiver can provide accurate navigation. These low-accuracy gyros and accelerometers are widely available.

#### Ball Bearings

The MTCR Annex controls radial ball bearings (Item 3.A.7.) with an ISO 492 tolerance class 2 (or ANSI/ABMA Std 20 Tolerance Class ABEC-9 or other national equivalents) or better and of a specified size. The size specification was geared toward capturing ball bearings usable in liquid propellant rocket engine turbo-pumps. However, for a variety of reasons, to include factors related to the production process for ball bearings and grading requirements, liquid rocket engine turbopump manufacturers in actuality use lower tolerance ball bearings.

In addition, radial ball bearings have other important missile-related uses. Spinning mass gyros used in inertial navigation systems frequently use ball bearings with a tighter tolerance than those used in liquid-propellant turbopumps, but of a different size than specified in the MTCR Annex: gyro manufacturers commonly use ABEC-9 class bearings or bearings manufactured or refinished to even closer tolerances, but the relatively small mechanical loads on these precision instruments do not warrant large-sized bearings as used in turbopump applications. The typical outside diameter for a gyro ball bearing is less than 15 mm, while the MTCR Annex regulates bearings between 25 and 100 mm.

Both of these examples indicate that there are a wide variety of ball bearings, usable in MTCR Category I systems that do not meet the MTCR Annex parameters for tolerance and/or size in Item 3.A.7. All MTCR Partners need to be aware of this when reviewing requests to export ball bearings.

#### Software for Modeling, Simulation or Design Integration

MTCR Annex Item 16.D.1. controls software specially designed for modeling, simulation, or design integration of the systems specified in 1.A. or the subsystems specified in 2.A. or 20.A. Per the technical note for item 16.D.1., the modeling software includes in particular the aerodynamic and thermodynamic analysis of the systems. The U.S. currently is seeing an increase in the amount of modeling, simulation and design software that is being used for missiles, due in part to the high cost of testing and the improvement in commercial modeling software. This trend is troubling because we believe programs of concern could exploit the MTCR's narrow definition of "specially designed" to obtain this software. If the interpretation of "specially designed" is implemented consistent with current MTCR Annex Terminology, many software

packages, which could be used for the development of MTCR Category I and II systems, would be left uncontrolled by the MTCR because few pieces of software have "no other purpose" than for use in the modeling of systems in item 1.A., or sub-systems in items 2.A or 20.A.

#### Hybrid Rocket Motors

Hybrid rocket motors contain elements of both solid and liquid systems, with the fuel being solid and the oxidizer being liquid. Item 2.A.1. controls individual rocket stages usable in systems specified in 1.A. as Category I items regardless of motor type. Item 2.A.1.c. controls liquid propellant rocket engines and solid propellant rocket motors as Category I items. However, hybrid rocket motors (and specially designed components usable in the systems specified in 1.A., 19.A.1. or 19.A.2.) are controlled under Item 3.A.6. as Category II items. Because of the high performance capability of hybrid rocket motors -- and their potential to be used in MTCR Category I missile development programs -- Partners need to carefully scrutinize applications to export hybrid rocket motors (and associated components, software and technology) and to be clear about their actual end-use.

As we have learned from the example of Space Ship One -- the first manned private rocket ship and winner of the international human spaceflight competition -- hybrid rockets can be used to push vehicles into orbit. Space Ship One also demonstrated that hybrid rocket motors can easily exceed the total impulse performance thresholds listed in paragraph 2.A.1.c. The success of Space Ship One, using hybrid rocket motors, also suggests the potential for a country/entity that desires to build a Category I rocket motor for use in ballistic missiles to try to obtain hybrid rocket motors or software or technology controlled under Category II, Items 3.D.2. and 3.E.1. They could use the Item 3 technology (i.e., hybrid rocket motor technology) to gain an understanding of Category I systems and as a stepping stone to building a propulsion sub-system for a Category I system. Moreover, by seeking Category II technology (Item 3), rather than the more-difficult-to-obtain Category I technology (Item 2) which is subject to a strong presumption of denial, their procurement efforts may be less likely to raise red flags with licensing officers.

#### Penetration Aids

Several devices and equipment to aid ballistic missile re-entry vehicle (RV) penetration may be employed on ballistic missile systems. Often these devices use old techniques, but technologies for these devices and equipment also are constantly improved to keep pace with advancements in electronics, radars and defense systems. A penetration aid can be defined as any device deliberately used to increase a missile or a warhead's chances of penetrating a target's defenses. This discussion examines only devices or equipment, not techniques such as target saturation, lofted trajectory, depressed trajectory, use of fractional orbit, or the use of electro-magnetic pulses (EMP).

**Chaff:** Chaff is an old technique used often with aircraft or ships to defeat homing missiles. When used in missiles it may be deployed over a large area of space, creating a large, radar-reflecting area that will obscure incoming warheads from defensive radar. A simpler way to generate a chaff field is the incidental or deliberate fragmentation of the final-stage rocket booster. This cloud of fragments can confuse an enemy's radar by creating a radar cross-section much larger than the actual warhead or RV and providing no defined target for the anti-missile system to home-in on.

**Jamming/Spoofing Devices:** Jamming a radar system is a technique that has long been used in aircraft. It can be used with an RV or post-boost vehicle (PBV) to confuse radar systems to prevent the radar from finding or tracking the warhead or RV. A variation of normal jamming can be used to spoof a radar system by generating false returns, thus allowing the real warhead or RV to reach its target. In

either case the radar system fails to track the warhead/RV and thus cannot provide information on the attack, to include warning.

**Decoys:** Decoys are used to confuse radar or electro-optical systems to the actual number and location of the real warhead(s). The decoy can be made from several different materials, such as mylar balloons that can be inflated in space. These mylar balloons are designed to have the same radar characteristics as the warhead or RV. Because the warhead and the decoy balloons may be at different temperatures, a more sophisticated system is to surround the warhead and the decoys with heated shrouds that put them all at the same temperature. This defeats attempts to discriminate between decoys and warheads on the basis of temperature.

**Stealth technology:** Stealth technology also could be an effective means to aid a warhead or RV in reaching its target. Stealth technology is already controlled in the MTCR Annex under Item 17.

Although countermeasure equipment that separates from the RV/PBV (e.g. decoys, jammers or chaff dispensers) are included in the MTCR's definition of "payload" for ballistic missiles, there are no MTCR Annex controls on penetration aids other than stealth technology.

## Conclusion

There are a number of technologies that are not part of the MTCR Annex but could make an important contribution to a country's missile program. Partners need to be mindful of this when evaluating the potential export license requests and to consider applying catch-all controls to prevent the export of these items to programs of concern.

END TEXT OF PAPER.

14. (U) Please slug any reporting on this or other MTCR issues for ISN/MTR. A word version of this document will be posted at [www.state.gov/demarche](http://www.state.gov/demarche).  
CLINTON